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FIFTH QUARTERLY PROGRESS REPORT

For Period October 1, 1967 to January 1, 1968

STERILIZABLE WIDE ANGLE GAS BEARING GYRO FGG334S

California Institute of Technology
Jet Propulsion Laboratory
Contract No. 951529

HONEYWELL | Aerospace Division

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NOTICE

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ABSTRACT

This document is the fifth Quarterly Progress Report, covering the period 1 October 1967 to 1 January 1968, for the Wide Angle Gas Bearing Gyroscope FGG344S, submitted in accordance with contract No. 951529. This report defines progress to date and technical problems encountered, and solved. Preparations have been made for discussions of modification No. 2 of this contract.

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ILLUSTRATIONS

SECTION I
PROGRESS

- Spinmotor lockup was eliminated.
- The decrease in g-capability caused by anti-lockup geometry was corrected.
- Four bi-weekly progress reports were written to document the lockup and g-capability problems.
- Preparations for contract negotiations of contract modification No. 2 were completed.
- The first gyro is being tested.

SECTION II
DISCUSSION

LOCKUP

The lockup problem is the inability to restart the motor when it has been stopped after continuous running for periods between 10 and 100 hours. Moisture in the gimbal parts evaporates into the gimbal atmosphere and is then pumped into the gas bearing where it condenses. This condensation allows the rotor to wring to the shaft when the motor slows down and the parts approach each other. The point of wringing-in is indicated by an abrupt stopping of the rotor on rundown. The motor can be restarted if sufficient time (several days) is allowed for the moisture to evaporate; the starting voltages also quickly return to original values with a few quick starts and stops. Running the motor for a few hours will repeat the cycle.

Drying the gas with a molecular sieve-type drying agent, combined with piece-part drying before assembly, extends the life of this motor but will not prevent the lockup from eventually occurring. Revised bearing patterning is necessary to accomplish the required life, while gas and piece-part drying will also be incorporated into the new gimbal assembly.

Lockup is prevented by using patterns which pump gas through the bearing assembly, as opposed to a lockup configuration where each thrust bearing develops equal pressure at the ends of the journal bearing and creates a high-pressure, zero-flow condition. By pumping gas through the assembly of thrust and journal bearings, the moisture is carried away faster than it can condense. This is accomplished by venting as discussed in the following paragraphs.

Thrust Venting

This process provided insufficient flow to remove the moisture. One motor was built and worked, but a second motor failed by locking-up. The thrust venting was implemented by building one thrust plate with a larger sealing band than the other plate (discussed in fourth Quarterly Progress Report on contract No. 951529). The g-capability was not noticeably affected by this process.

Journal Venting (Center Vent)

This process was successful in preventing lockup, but reduced the g-capability to an inadequate level. The journal bearing was vented with a hole in the center of the bearing, which allowed the thrust bearing to pump gas through the journal and out its center vent hole. This venting of the thrust plates, combined with the L/D (length/diameter) change of the journal bearing and reduced ambient pressure for the journal bearing, reduced the g-capability where 200 g-shock was beyond the capability of this configuration.

Journal Venting (Asymmetrical Pattern)

This process was the most successful in preventing lockup. It also reduced the g-capability by a lesser extent than journal venting (center vent). Lock-up is prevented by removing the moisture faster than it can condense, but the L/D ratio and the ambient pressure of the journal bearing is retained. The thrust bearing g-capability is still affected by a flow through the bearing, but to a lesser extent.

G-CAPABILITY

In the process of eliminating the lockup problem, the g-capability in the thrust direction was reduced because of the flow through the bearing required to prevent the lockup. This reduction has been countered with a new thrust bearing pattern which increases the g-capability at high frequencies.

Three spiral grooves are used on the thrust bearing instead of the six previously used. The result is a 10 percent increase in thrust g-capability between 500 and 1000 Hz as shown in Figure 1. The indicated g-capability in Figure 1 does not take into account any bending of parts and other fixture errors such as transducer electrical inputs with external g-forces. These errors could be measured with more extensive testing techniques already developed; however, as this program is more concerned with motor existence than with accurate displacement information, motor synchronism is used as the final test of the spinmotor. The displacements measured under shock and sine wave testing are very useful in identifying problems, as the ringing under shock is a significant problem in this motor as opposed to the GG159 C and D type spinmotors. The higher power of the earlier motors resulted in higher frequency resonances which were not as easily excited by the shock pulse. The damping of the gas bearing was also greater in the previous design. Figure 2 shows the ringing which occurs at 200 g's on this latest spinmotor when shocked with a 200-g, 1.5 millisecond shock pulse.

This new motor was subjected to the required random noise, random noise plus sine wave, and shock testing with no loss of synchronization between the physical position of the wheel and the electrical position of the excitation voltage. This is observed by creating an oscilloscope lissajous pattern with the output of the Dynagage capacitance displacement transducer and the motor excitation voltage. Synchronism slips of one degree can be observed with this technique.

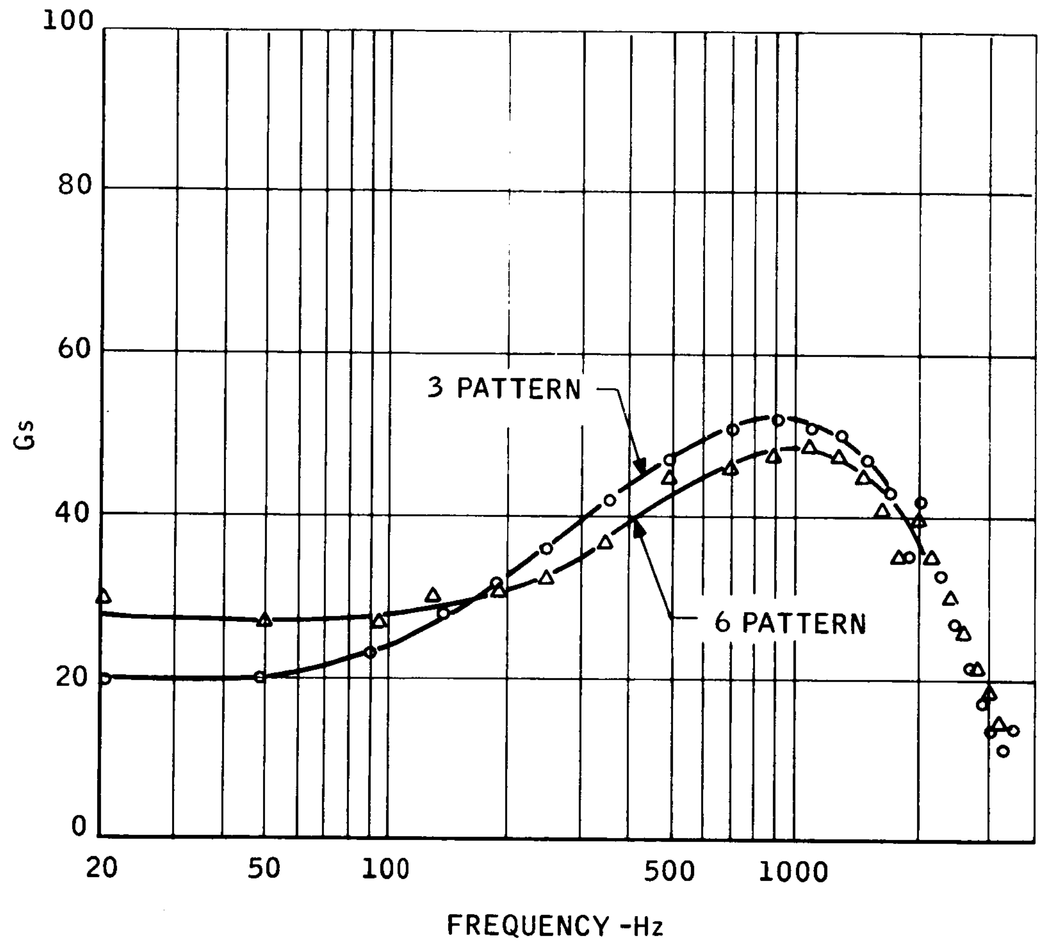

Figure 1. GG334S Thrust Bearing G-Capability with Six and Three Pattern Thrust Plates

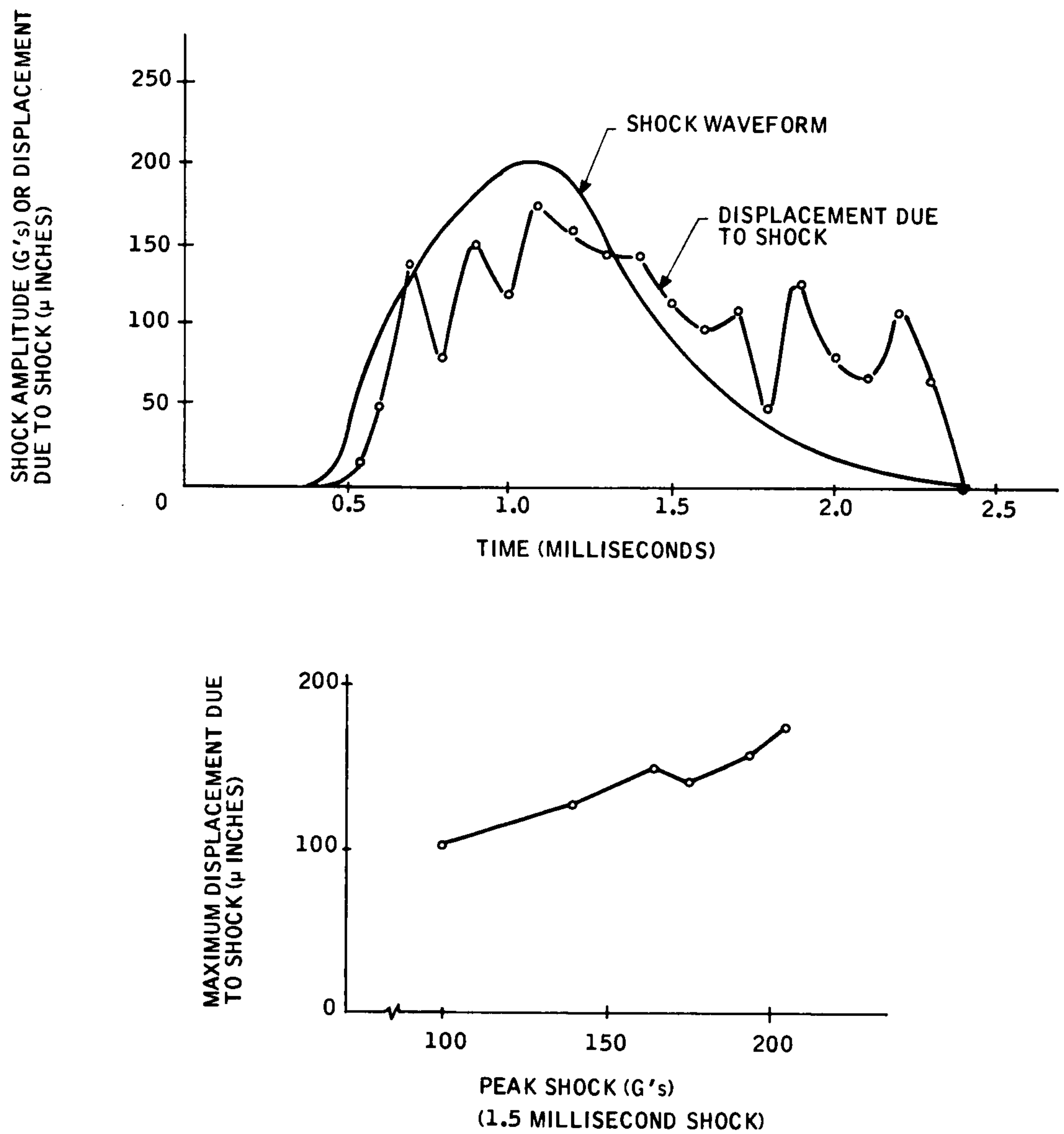

Figure 2. GG334S Gas Bearing Spinmotor (Thrust Bearing Shock)

The critical area in this motor is still the thrust bearing g-capability. Synchronism slip can occur with greater than 200-g, 1.5 millisecond shock pulse. This potential problem becomes less critical when two facts are considered:

- The g-capability under 1.0-millisecond shocks is 20 to 40 g's greater than that under 1.5-millisecond duration. As the JPL shock is between 0.5 and 0.9 milliseconds in duration, this creates more margin when the device is actually used than with the contract requirement of 1.5 milliseconds. (The ability of Honeywell to test with less than 1.5 milliseconds half sine wave shock is a recent development.)

- The torque created by the displacement of the gas bearings rises sharply when high bearing displacements are reached. Previous testing on the GG159 C and D motors showed that bearing contact (scratched parts when disassembled) occurred when synchronism slip was observed. This has not been the case with the GG334S/GG159E motors, and the reason is that the crown of the recent motors has been less than that of the older ones. This crown is present on the thrust surfaces and creates a high-center region on the rotor, to contact with the flat thrust plates. The center contact reduces starting torque requirements which would be higher if the outer radius of the thrust bearing supported the rotor weight. Also, better orthogonality is obtained with the single-piece journal bearing. These geometrical considerations show that the difference between a flat plate assumption and the actual physical configuration is a bearing which will contact at about 0.85 eccentricity -- i.e., nonflatness and orthogonality buildup of 12μ inch.

Figure 3 shows that a torque margin of two is exceeded with an eccentricity of 0.7, creating an additional g-capability of 40 g's = (0.85/0.7) (200) - (200). This effect has been observed in the GG334S/159E spinmotor where synchronism has been exceeded and no indication of bearing contact (scratches) could be seen. Figure 3 also shows that journal bearing eccentricities of 0.85 and a torque margin of two occur simultaneously. The journal bearing capability was not exceeded during testing; therefore, no experimental evidence exists.

GYRO TESTING

The gyro which was built with the thrust vented motor (reported in bi-weekly progress report number three) has received low-priority testing. The gyro is not considered a shippable device for two reasons:

- The spinmotor is of a configuration which could lockup at some future date
- The gyro fill was not good and processes are being changed to correct this.

The fill problems can be corrected; but the gyro is now being used to determine general testing such as sterilization and shock performance. This data will be generated in the next few weeks.

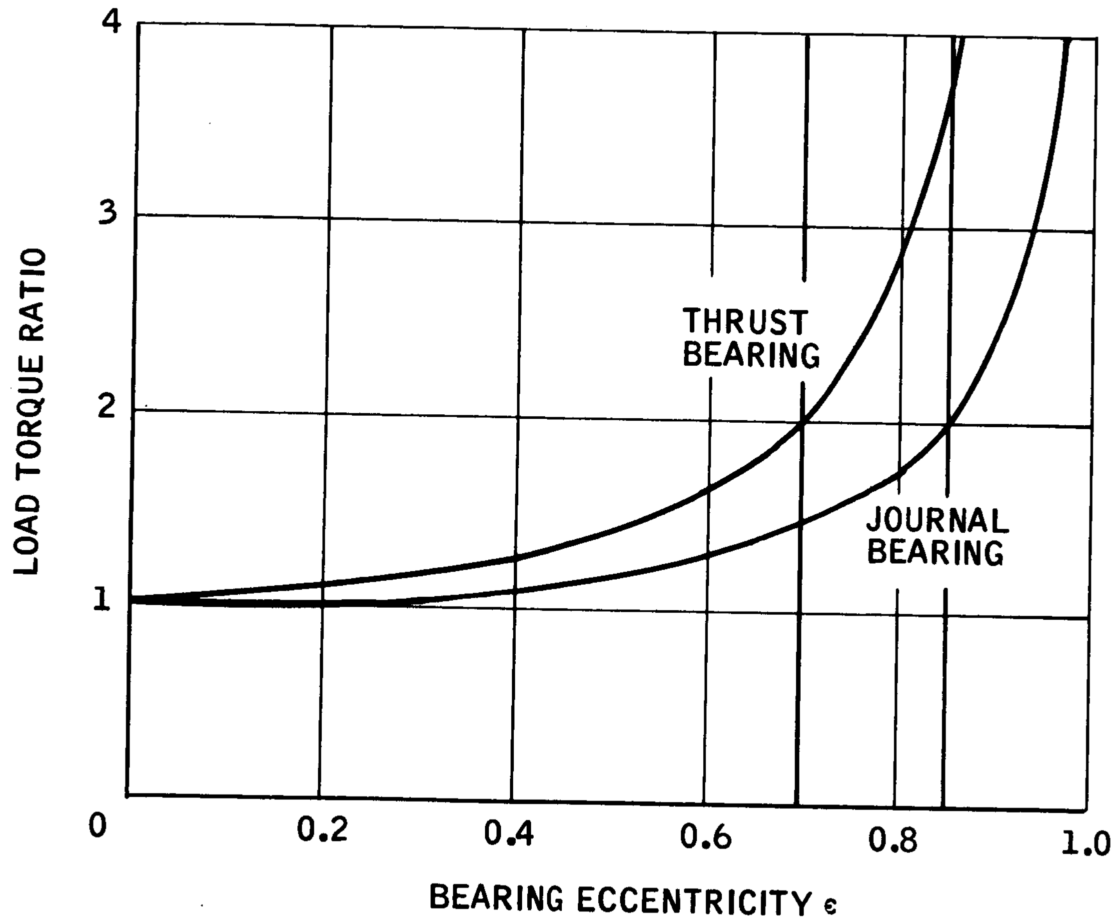

Figure 3. Thrust and Journal Bearing Theoritical Load Torque Increase with Bearing Displacement

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SECTION III
SCHEDULE

The negotiations on modification No. 2 of contract No. 951529 will determine the shipping dates for the five gyros to be built. Work will continue on gyro assembly during this negotiation period.

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